Jet Propulsion Laboratory
California Institute of Technology

# Break the Chain and Containment Assurance Concepts for Mars Sample Return and Beyond

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# Break the Chain and Containment Assurance



- Extremely improbable that Mars material poses a threat to Earth's biosphere
  - A Mars microbe is unlikely to be pathogenic to Earth life not part of its evolution
  - Large quantities of Mars meteorites have been delivered to Earth over time
  - U.S. National Academies (through their National Research Council) and the corresponding European agencies agree that the risk is low, but recommend robust containment of unsterilized material for an extra margin of safety

- NASA procedural requirements (NID 8020.109A):
  - "Unless the sample to be returned is subjected to an accepted, approved, sterilization process, the sample container must be sealed after sample acquisition, and a **redundant, fail-safe containment** with a method for verification of its operation before Earth-return shall be required."
  - "The mission and the spacecraft design shall provide a method to **"break the chain of contact" (BTC)** with Mars. No uncontained hardware that contacted Mars, directly or indirectly, may be returned to Earth unless sterilized..."

- MSR study is not working to an a priori quantitative requirement for containment assurance, but are striving for an extraordinary level of robustness

# Notional Simplified Martian Material Control

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| | | Mars Surface | MAV Launch | Mars Orbit Rendezvous | Mars Orbit Processing | Return To Earth | EEV Earth Entry | Post Landing |
|---|---|---|---|---|---|---|---|---|
| **Source** | | Atmosphere and Surface Sample Tubes | | [Orbital Dust and Moons] Release of Carried Particles | | Release of Carried Particles | | |
| **Environmental** | **Transport** | • Aeolian<br>• Gravity<br>• Emission | • Aero stripping<br>• Dynamic<br>• Emission | • Emission<br>• Orbital dynamics (dispersion)<br>• Solar pressure (deorbit) | | | • Aero stripping<br>• Dynamic<br>• Emission | • Earth environment<br>• Ground handling |
| | **Sterilize** | • UV | • Aero heating<br>• UV | • UV<br>• Vacuum effects | | | • UV<br>• Aero heating | • Earth environment (chemical) |
| **Engineered** | **Transport (Contain)** | • Temp barriers<br>• Sealed zones | • Sealed zones | | • Sealed zones<br>• **Contain** | | | |
| | **Sterilize** | • Heat<br>• Chemical<br>• UV LED | | | • Heat<br>• Chemical<br>• UV LED<br>• Plasma | • Heat<br>• Chemical<br>• UV LED | | • Heat<br>• Chemical<br>• UV LED<br>• Other? |

*The above represents an option space, not the instantiation of a single architecture*

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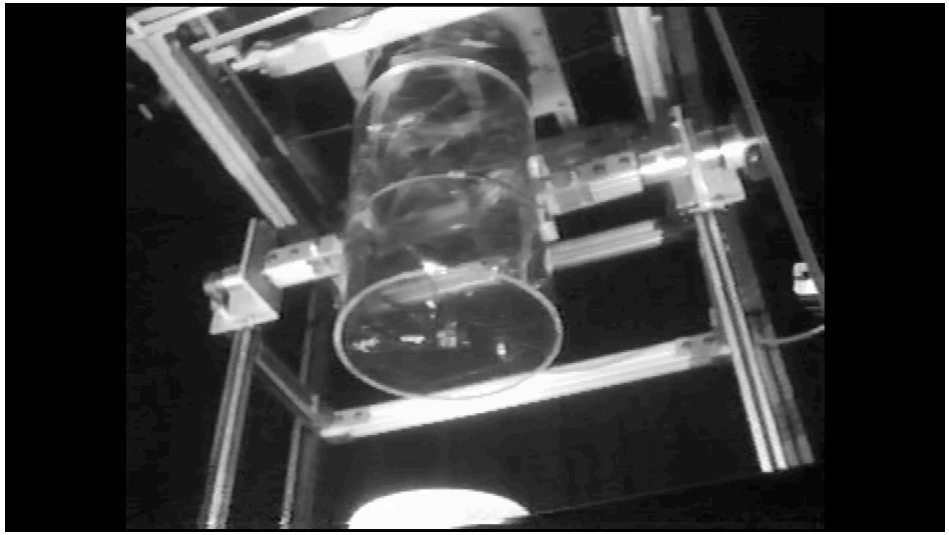
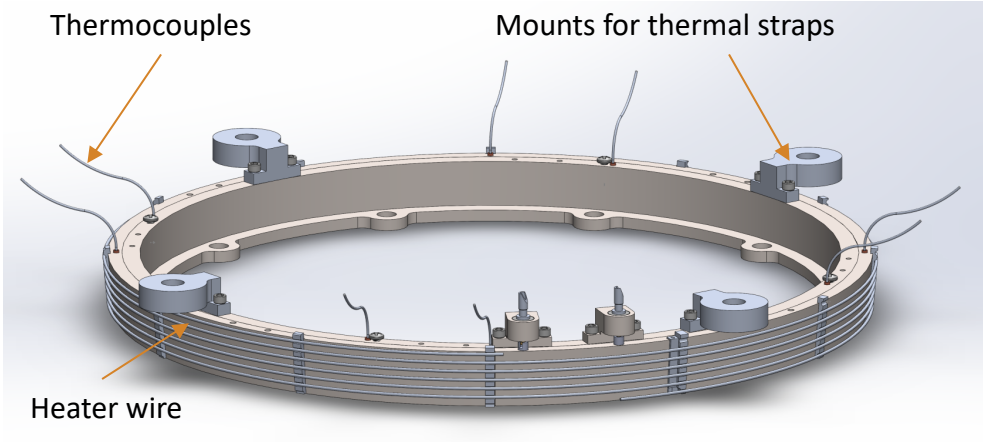
# Break the Chain Technology Development



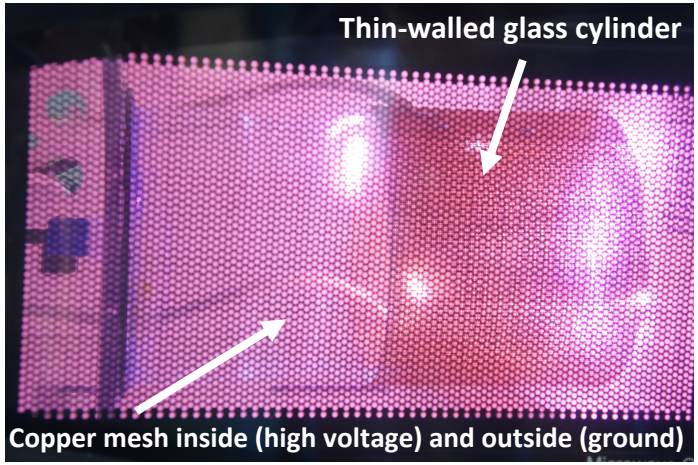
Subscale Inductive Brazing Technology Development



Full Scale Bagging Demonstration (JPL/ILC Dover/APL)




Resistive Braze System Development




Dielectric Barrier Discharge and Microwave Plasma Sterilization (JPL/Drexel)

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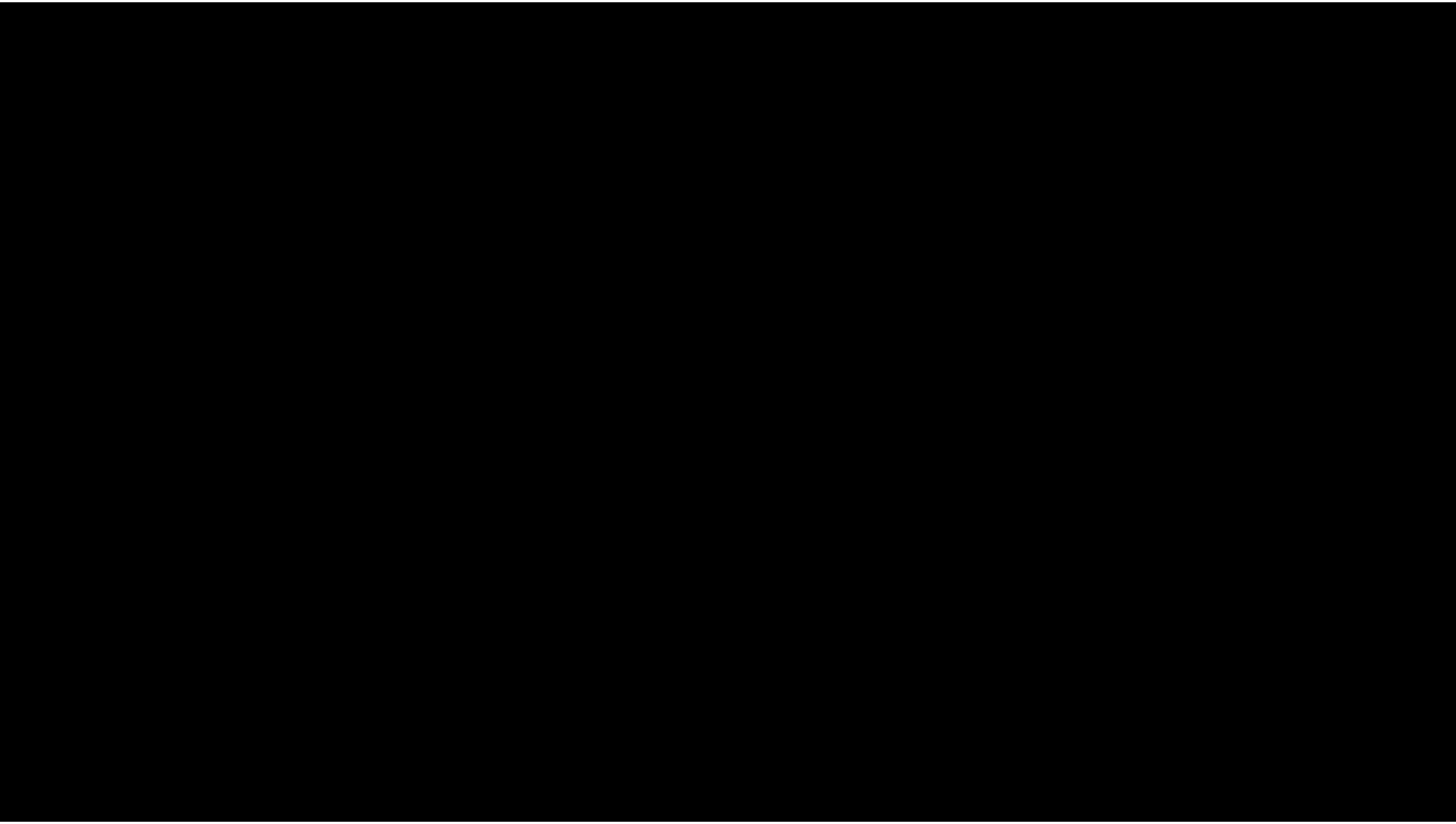
# Baseline Capture, Contain, and Return System





# Work Forward



- Engaging industry and academia through a Sterilization Working Group to assess the sterilization or inactivation of Martian material
  - Sterilization based on life as we know it, but adapted for heartier organisms
  - Heat, chemical, plasma, UV, and other modalities are being considered
  - Assessing biological indicators to validate sterilization technologies

- With sterilization techniques becoming more defined, moving towards holistic architecture that addresses surface to surface material transport
  - This includes assessing containment strategies, impact tolerance, etc.

- As team pushes to understand sterilization and containment mechanisms for safe sample return, benefits expected for other missions
  - New methods and relaxed requirements for forward planetary protection
  - Robust architectures for sample return from other science targets

# Backup

# Breaking the Chain of Contact Using Brazing

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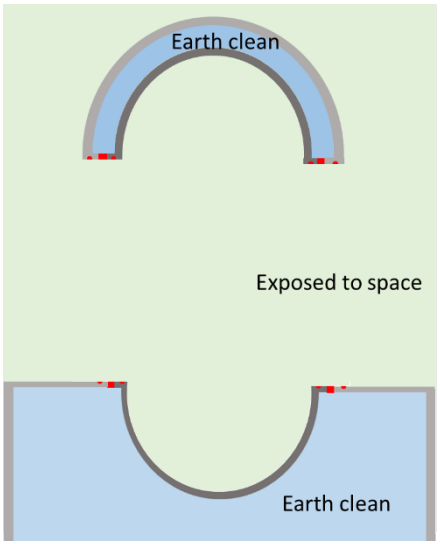
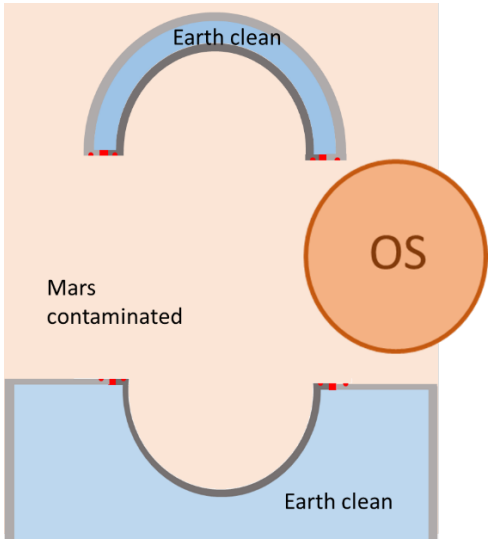
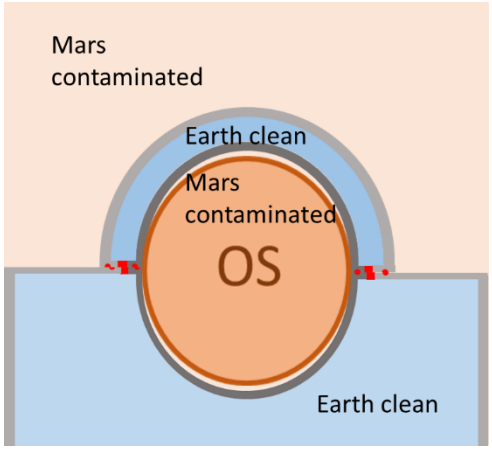


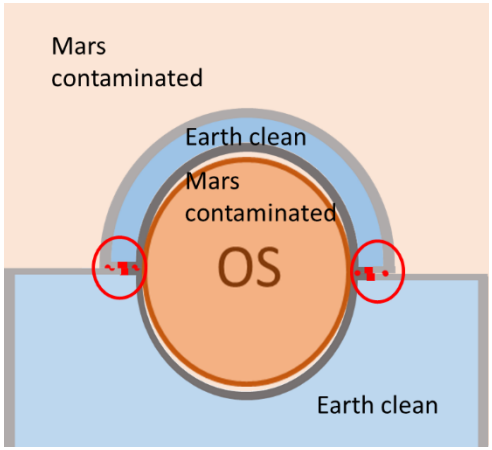

In space



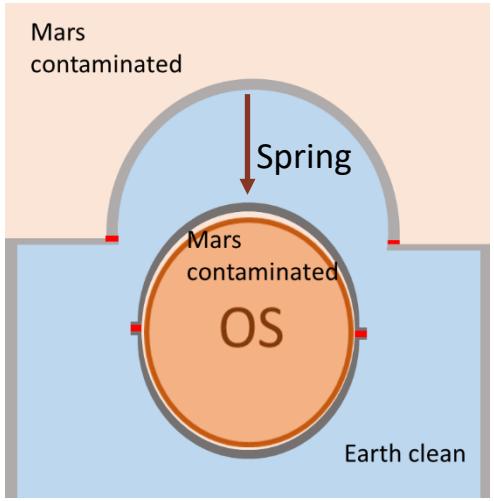

OS capture



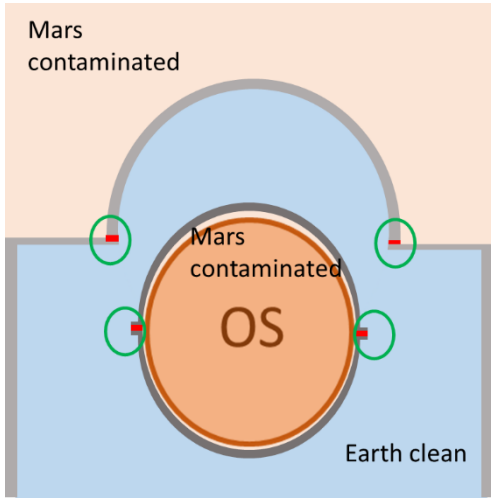

Enclose OS




Activated heating
(Sterilizing and Sealing)




Separation




Passive cooling (Seaming)

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